Heat Transfer (1)

23/2/2016

سكشن [II] انتقال حرارة

[9]

* Modes of heat transfer:-

[I] Conduction heat transfer.

Forier's Law.

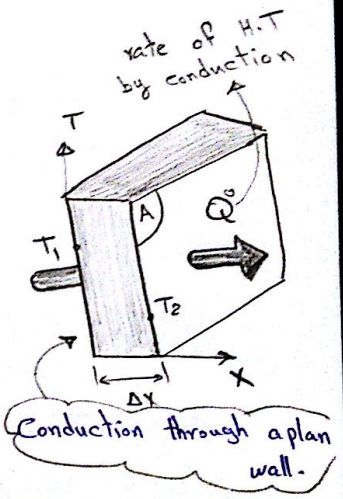
$$\dot{Q}_{cond} = -K A \frac{dT}{dx}$$ and For steady Flow of heat.

$$\frac{dT}{dx} \text{ (Temperature gradient)} = \frac{\Delta T}{\Delta x}$$

and $\dot{Q}$ become $\dot{Q} = -KA \frac{\Delta T}{\Delta x}$

where $\Delta T = T_2 - T_1$

$$\dot{Q} = KA \frac{(T_1 - T_2)}{L}$$



Conduction through a plan wall.

where

$\Delta x = L$: Thickness of plane wall..

K :- Thermal conductivity of wall material which is known as the ability of material to conduct heat energy.

A :- Area normal to the heat transfer direction.

ΔT : Temperature difference between two points.

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(b)

sheet No. 1 :- Modes of heat transfer

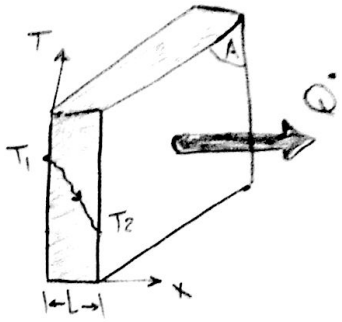
Prob (1) Brick wall

$A = 5\,m * 6\,m = 30\,m^2$

$\Delta x = L = 30\,cm. = 0.3\,m.$

$K = 0.69\ W/m^\circ.C.$

$T_1 = 20^\circ C$ and $T_2 = 5^\circ C$



Required :- $\dot{Q}_{cond} = ?!$? ← (W) Energy.

Solution

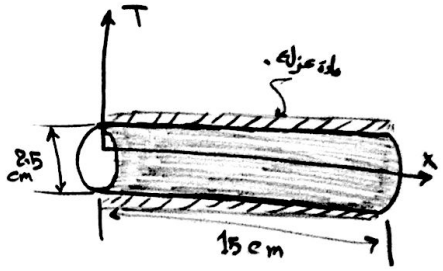
$$\dot{Q} = -AK\frac{dT}{dx} = KA\frac{(T_1 - T_2)}{L} = 0.69 * 30\,\frac{(20-5)}{0.3} = 1035\ W$$

Prob (2) specimen of metal

$D = 2.5\,cm.$ $T_1 = 100^\circ C$

$L = 15\,cm.$ $T_2 = 20^\circ C$

$\dot{Q} = 3\ W$



Required :- $K = ?!\ W/m.C^\circ$

$$A = \frac{\pi D^2}{4} = \frac{\pi * (2.5 * 10^{-2})^2}{4} =$$

$$K = \frac{\dot{Q}.L}{A(T_1 - T_2)} = \frac{3 * 0.15}{A(100 - 20)} = 9.16$$

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(c)

$$I = \frac{\Delta V}{R_{electrical}} \quad \text{بالمثل} \quad Q^\circ = K A \frac{(T_1 - T_2)}{L}$$

I: معدل سريان الشحنات الكهربية.

ΔV: فرق الجهد (القوة الدافعة الكهربية).

$R_{electrical}$: مقاومة كهربية

Q°: معدل سريان الحرارة

$T_1 - T_2$: فرق درجات الحرارة.

$$R_{th} = \frac{L}{KA}$$

R_{th}: المقاومة الحرارية

* بشرط (الهواء في حالة السكون).

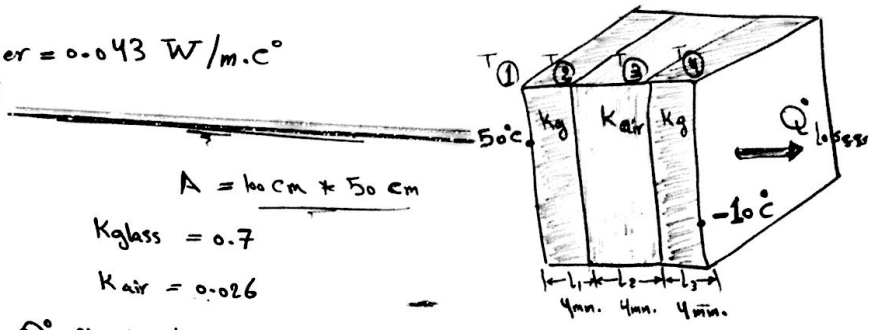
$K_{air} = 0.026 \ W/m.c^\circ$

$K_{glass} = 0.7 \ W/m.c^\circ$

$K_{glass\ Fiber} = 0.043 \ W/m.c^\circ$

ألياف زجاجية.

في حالة (conduction) plane wall.



(composite wall)

$A = 100\ cm * 50\ cm$

Prob : 3

$K_{glass} = 0.7$

$K_{air} = 0.026$

Required $Q^\circ = ?!$ (W).

solution.

For composite wall

$T_1 \ R_1 \ T_2 \ R_2 \ T_3 \ R_3 \ T_4$

$$Q^\circ = \frac{\Delta T}{\Sigma R_{th}} = \frac{50 - (-10)}{\Sigma R_{th}}$$

$$R_{th})_{total} = R_{th_1} + R_{th_2} + R_{th_3}$$

$$Q^\circ = \frac{60}{0.3304} = 181.598 \ W$$

$$R_{th})_{total} = \frac{1}{A}\left[\frac{L_1}{K_1} + \frac{L_2}{K_2} + \frac{L_3}{K_3}\right]$$

$$R_{th})_{total} = \frac{1}{1 * 0.5}\left[\frac{0.004}{0.7} * 2 + \frac{0.004}{0.026}\right]$$

$$R_{th})_{total} = 0.3304$$

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[d]

Prob. [4] **Note.** For steady Flow of heat transfer.

Q° is the same For all Layer's which equal the Q°_{total}

$$Q^\circ = \frac{T_1 - T_4}{R_1 + R_2 + R_3} = \frac{T_1 - T_2}{R_1} = \frac{T_2 - T_3}{R_2} = \frac{T_3 - T_4}{R_3} = \frac{T_2 - T_4}{R_2 + R_3} = \frac{T_1 - T_3}{R_1 + R_2}$$

Solution

$$Q^\circ = \frac{T_1 - T_2}{R_1} = \frac{50 - T_2}{0.0114} = 181.5 \text{ W}$$

$T_2 = 47.9309\ ^\circ C$

$$Q^\circ = \frac{T_3 - T_4}{R_3} = \frac{T_3 - (-10)}{0.114} = 181.5 \text{ W}$$

$T_3 = -7.9309\ ^\circ C$

$$R_3 = R_1 = \frac{L_1}{k_s \cdot A} = \frac{4 * 10^{-3}}{0.7 * 0.5} = 0.0114$$

$$R_2 = \frac{L_2}{k_{air} \cdot A} = \frac{4 * 10^{-3}}{0.026 * 0.5} =$$

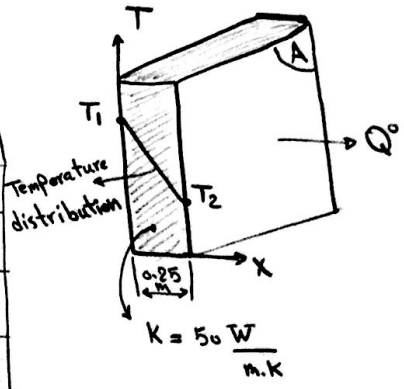
$T_1 = 50^\circ C$

$T_2 = -10^\circ C$

$Q^\circ = 181.5$ W

Prob. [5]

case	T_1	T_2	dT/dx (K/m)	$q^\circ = \frac{Q^\circ}{A}$ (W/m^2)
1	400 K	300 K		
2	100 °C		-250	
3	80 °C		200	
4		-5 °C		4000
5	30°C			-3000



$$Q^\circ = -KA\frac{dT}{dx} = KA\frac{(T_1 - T_2)}{L} \quad \text{and For unit area } A = 1 m^2$$

$$q^\circ = \frac{Q^\circ}{A} = -K\frac{dT}{dx} = K * \frac{(T_1 - T_2)}{L}$$

↳ Heat Flux (W/m^2).

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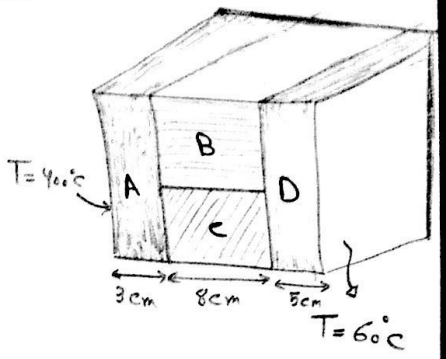
e) * Prob. 5



$K_a = 50\ W/m^\circ.C$

$K_b = 30\ W/m^\circ.C$

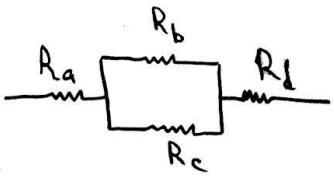
$K_c = 65\ W/m^\circ.C$

$K_d = 50\ W/m^\circ.C$

$A_d = A_a = 1\ m^2$

$A_b = A_c = 0.5\ m^2$

Solution



$$\Sigma R_{th} = R_a + R_{b//c} + R_d$$

$$R_{b//c} = \frac{R_b * R_c}{R_b + R_c} =$$

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